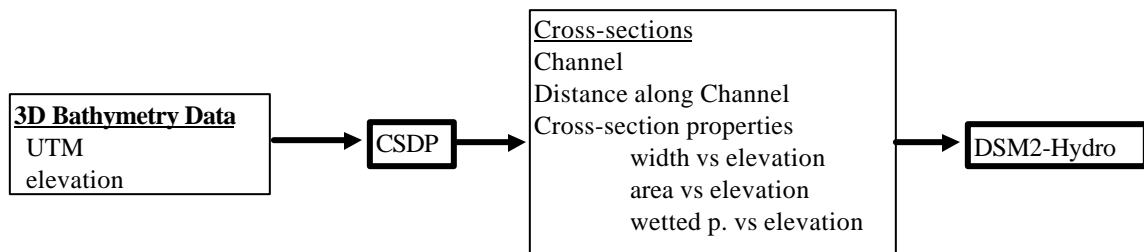


# Cross-Section Development Program(CSDP) Version 2.22

## Introduction

Bathymetry data are not used directly by DSM2-Hydro; they are used by the Cross-section Development Program(CSDP) to draw cross-sections which are approximations to the actual shape of each channel. The cross-section drawings are used by the CSDP to calculate cross-section property tables, which are used by Hydro. Cross-section properties used by Hydro include area, width, and wetted perimeter(Figure 6-1). This process allows the user to reduce the amount of data to a minimal representative data set, which is the smallest amount of data required to describe the general shape of the delta's channels. Also, the user has the ability to change the shapes of cross-sections to simulate proposed changes in geometry, such as dredging.

The most important part of the process is the selection of data used to draw each cross-section. The data selection process allows the user to place more emphasis on data that are most reliable and most representative.



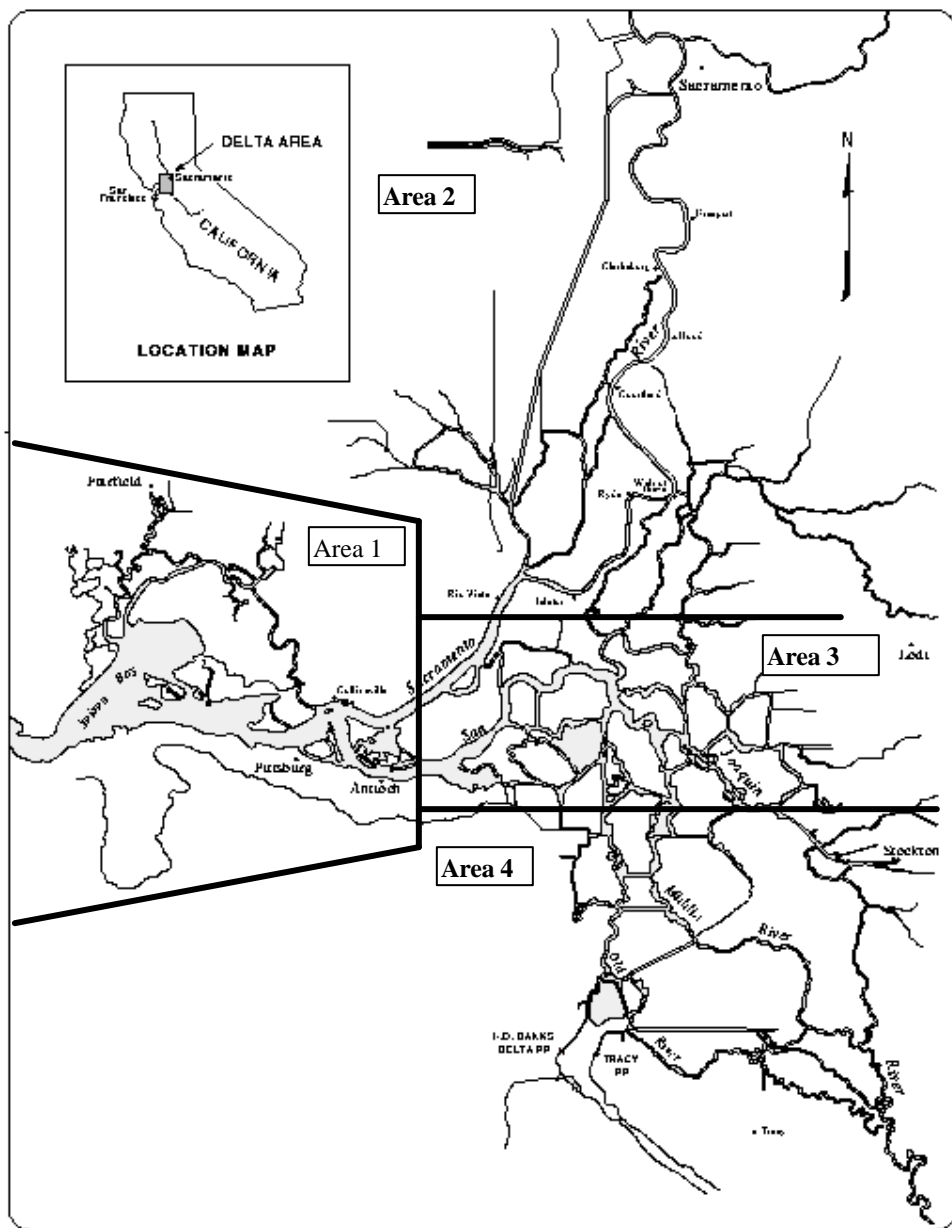
**Figure 6-1. The CSDP is used to convert 3D bathymetry data for use by DSM2-Hydro**

## Bathymetry Data

The bathymetry database contains over 400,000 points, and has been divided in to four files:

filename	location
area1.cdp	western Delta, Suisun Bay, Suisun Marsh
area2.cdp	north Delta
area3.cdp	central Delta
area4.cdp	south Delta

Figure 6-2 shows the location of each of the four areas.



**Figure 6-2: Delta Bathymetry data are divided into 4 areas**

The CSDP is designed to work with **three dimensional bathymetry data**, which have two horizontal coordinates in UTM zone 10, and a vertical coordinate in feet with respect to the National Geodetic Vertical Datum of 1929 (NGVD 1929) (Figure 6-3). It is also possible to use data that are not referenced to a global coordinate

system(non-georeferenced data), but some manipulation is required. Examples of non-georeferenced data that can be used include **cross-section plots** and **cross-section station and elevation coordinates** (Section 2).

9	626955.4555	4186009.9708	2.60	1990	DWR-CD.MAY	D-DC100
	626955.7598	4186009.9874	1.60	1990	DWR-CD.MAY	D-DC100
	626957.2816	4186010.0705	0.90	1990	DWR-CD.MAY	D-DC100
	626958.8033	4186010.1536	0.60	1990	DWR-CD.MAY	D-DC100
	626960.3250	4186010.2367	0.20	1990	DWR-CD.MAY	D-DC100
	626961.8468	4186010.3198	-0.10	1990	DWR-CD.MAY	D-DC100
	626963.3685	4186010.4029	-0.16	1990	DWR-CD.MAY	D-DC100
	626964.8902	4186010.4861	-0.47	1990	DWR-CD.MAY	D-DC100
	626966.4120	4186010.5692	-0.94	1990	DWR-CD.MAY	D-DC100
Column	Description					
1	west/east UTM zone 10 coordinate					
2	north/south UTM zone 10 coordinate					
3	elevation, ft(NGVD 1929)					
4	year of survey					
5	source of data or name of survey					
6	description of data point(currently not used)					

**Figure 6-3: Three dimensional Bathymetry data**

## 1. CSDP input files

**Bathymetry Data:** .prn, .cdp, .cdp.gz

**landmark data:** \*.cdl


**network data:** \*.cdn

**channel connectivity data:** \*.inp

**Bathymetry Data:** .cdp, .prn, or .cdp.gz

Bathymetry data can be stored in ascii(.prn) files, binary(.cdp) files, or Gzipped binary files(.cdp.gz). The use of binary files allows faster access. Gzipped files are smaller, but take more time to read.

**Landmark Data:** .cdl

Landmark files are only read by the CSDP, and are not used directly by DSM2. A landmark file consists of labels and UTM coordinates. Landmark files can be used to label any feature, such as a node or a cross-section. The file delta.cdl is created by the CSDP when the  button (Network-Calculates) is clicked and is used to label cross-sections drawn by the user. It can be used to help locate cross-section lines.

The file `node.cdl` contains coordinates for every node in the May 1995 version of the DSM model grid. This file is used by the `create DSM chan` function which is in the Centerline menu.

### Network Data: `.cdn`

Network files are only read by the CSDP, and are not used directly by DSM2. A network file contains the data set that is created by the user, including centerline names, centerline coordinates, and cross-section coordinates.

### Channel Connectivity data: `*.inp`

The file `channels.inp` contains the CHANNELS input section (Chapter 5). The CHANNELS input section includes the numbers of all channels in the model grid and the numbers of the upstream and downstream nodes of each channel. The file `channels.inp` is used by the CSDP to draw centerlines for specified DSM channel numbers.

## 2. Using the CSDP

- loading bathymetry
- loading network data
- loading landmark data
- selecting data
- drawing cross-sections

Version 2.22 of the CSDP includes an improved toolbar (Figure 6-4a). Most of the commonly used features are now linked to buttons in the toolbar. Toolbar buttons include Tool Tip Text, which displays a brief description when the mouse cursor is hovered over the button.

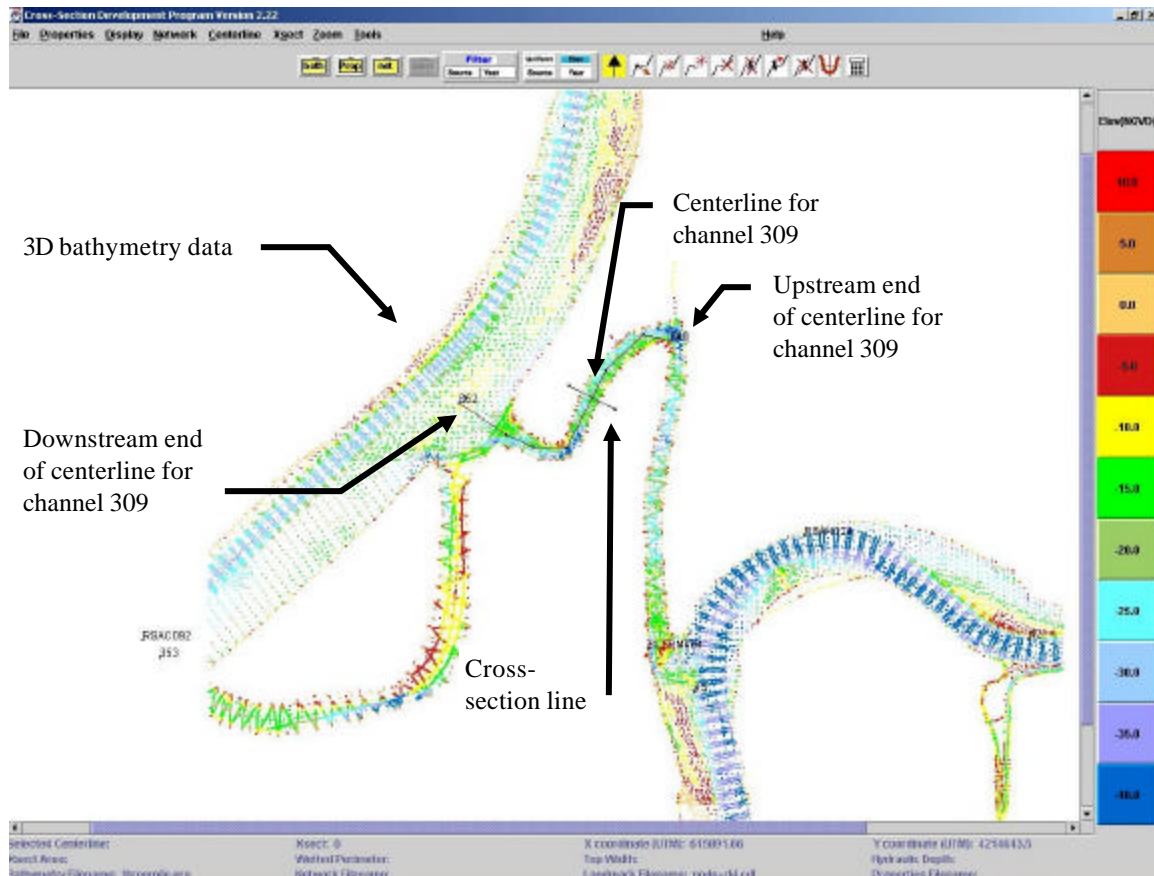


Figure 6-4a: Toolbar with and without Tool Tip Text displayed

### Loading Bathymetry Data


To load a bathymetry file, select the `File-Open` menu item or click the `bath` button and select the file you wish to load. The file should be an ascii file with a `.prn` extension, a binary file with a `.cdp` extension, or a Gzipped binary file with a `.cdp.gz` extension. After loading a `.prn` file, you can save it as a `.cdp` file for faster access.

After specifying a filename, the file will be read and the data will be displayed in plan view(Figure 6-4b). The points will be colored by elevation by default. Points can also be colored by year, source, or uniformly by selecting the Display-Color By menu item or by clicking the *Uniform*, *Elev*, *Source*, or *Year* buttons on the toolbar.



**Figure 6-4b: Cross-Section Development Program(CSDP). Bathymetry data, plan view. Centerline for DSM channel 309 with cross-section line.**

### Loading Network data


To work with an existing network file, select the Network-Read menu item or click the  button and select the file you wish to load. If there is any unsaved network information in memory, you will have the opportunity to save it. A network file will always have a .cdn extension. To remove the network from the display and from memory, select the Network-Clear Network menu item.

### Loading Landmark data

To load a landmark file, select the Display-Landmark menu item and select the file you wish to load. A landmark file will always have a .cdl extension. To remove the

landmarks from the display and from memory, select the Display-Clear Landmarks menu item.

### Loading a Properties file

A properties file is used to store program options. Currently, properties files store only the colors that are set in the legend toolbar. To load a properties file, select the Properties-Load Menu Item or click the  button on the toolbar.

### Loading a Channel Outline file

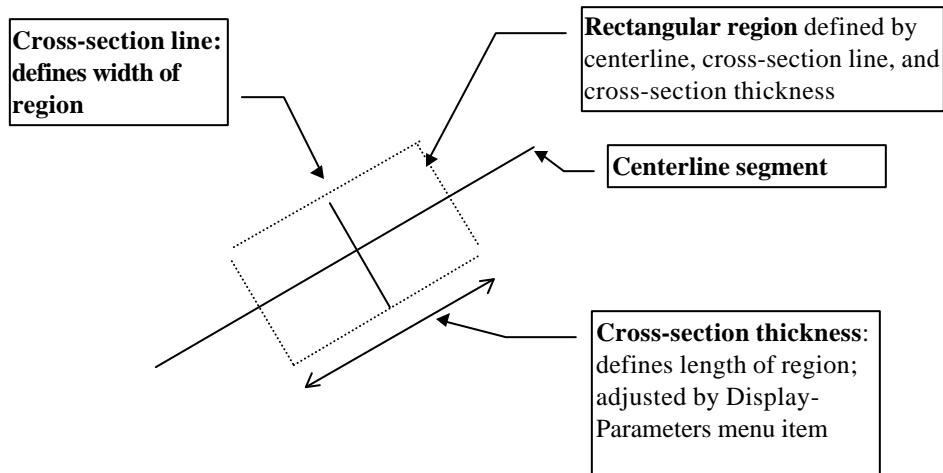
Channel outline files have a .cdo extension. To load a channel outline file, select the Display-Digital Line Graph (Channel Outline) menu item. This function is not designed to read USGS Digital Line Graph files. It is designed to read a file which is available on the CSDP web page.

### Selecting Data

It is the user's responsibility to select data for drawing cross-sections with the CSDP. Criteria for selection include year, source, and location. Because cross-sections are interpolated along channels, cross-sections should be representative of the overall shape of the portion of the channel that they represent. There should generally not be large changes in area, width, wetted perimeter, or bottom elevation among the set of cross-sections used to describe any given channel. Data are selected by using two perpendicular lines to define a rectangular region. All of the data contained within this region are then displayed in the cross-section view.


1. To zoom in on the display, select the Zoom-Factor menu item. Use the scroll bar to select a new zoom factor. Entering a zoom factor greater than 1 will increase the size of the display. Use the scrollbars to scroll through the data display.
2. To increase the bathymetry point size after zooming, select the Display-Parameters menu item. Enter an integer.
3. To filter the data display, click on the Source or Year buttons on the toolbar. This will allow you to "turn off" the display of undesirable data. (Note: this step is optional. Filtering the data display may or may not facilitate the selection of appropriate data).
4. Select a **rectangular region** of data to be displayed in cross-section view (Figure 6-5). The region will have a length, width, and direction. The location, length, width, and direction are used to select data to be displayed in cross-section view. The direction defines the positive flow direction for the channel. The direction also determines the order in which points will be displayed, which will always be from left bank to right bank (Figure 6-7). DSM2 currently does not require points on the left to be on the left bank, but in the future, some DSM2 models may have this requirement. The length of the region is defined by the

cross-section thickness, which can be adjusted by selecting Display-Parameters. The width is defined by the length of the cross-section line. The direction is defined by the order of the points in the centerline. The location of the center of the region is defined by the intersection of the centerline and the cross-section line.



**Figure 6-5: Rectangular region defined by centerline and cross-section line that is used to select data to be displayed in cross-section view**

- a. **Create a centerline:** Select Centerline>Create DSM Chan. You will be asked to select a *channel connectivity file*, if one is not already loaded. The channel connectivity file is the file that contains the CHANNELS input section(Chapter 5), and will typically be named **channels.inp**. You will then be asked to enter the DSM channel number for the centerline you wish to create. Enter a number from the DSM model grid. Finally, you will be asked to select a *landmark file*, if one is not loaded or if one or both of the nodes for the specified channel number are not found. Select the file **node.cdl**, which contains the locations of the nodes in the DSM model grid. A Centerline will be drawn from the upstream node of the specified channel to the downstream node(Figure 6-6a).
- b. **Insert centerline points:** Insert points into the centerline to create centerline segments which follow the shape of the channel (Figure 6-6b).

To insert points, select the centerline by clicking on it, click on the  button to turn the insert mode on, and then click at various locations along the channel to insert points. It is not necessary for the centerline to follow the exact shape of the channel; it is only necessary to have line segments which are aligned with the data you wish to use.

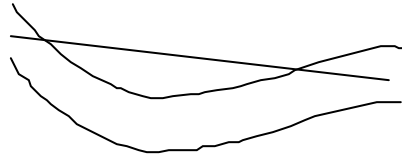


Figure 6-6a: Centerline created by *create DSM Chan* feature

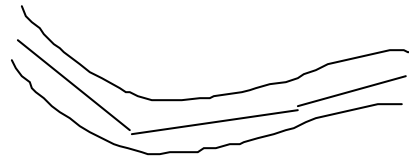



Figure 6-6b: Centerline with inserted points

## 5. Add cross-section

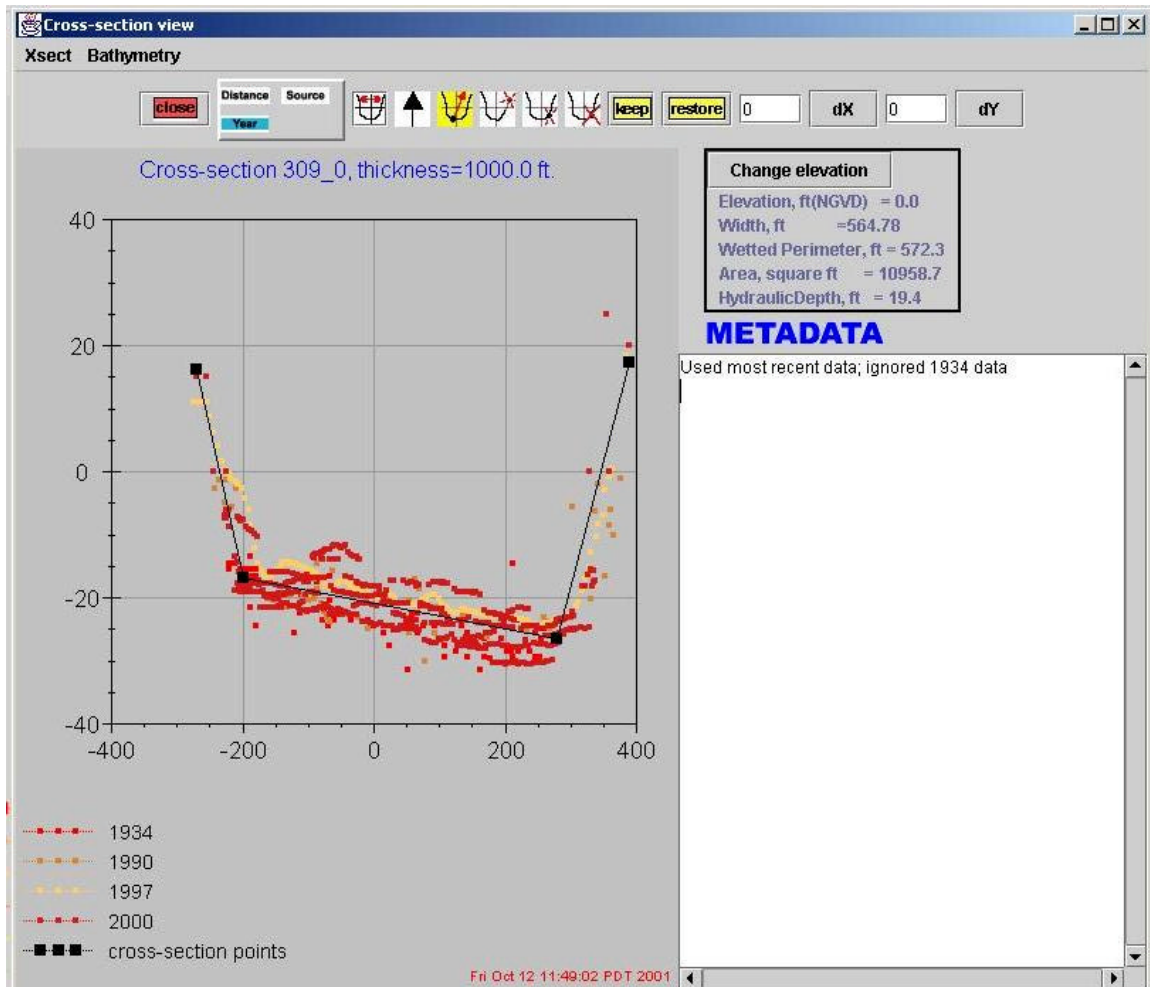
- a. **add cross-section line(s):** To add a cross-section line, click on the  button to turn the add cross-section mode on. Click on a location near the data you wish to use. A cross-section line will be drawn perpendicular to the nearest centerline segment. The cross-section line should be aligned with the data you wish to view. If it is not, you may need to move the endpoints of the centerline segment which intersects the cross-section line.
- b. **Adjust the cross-section thickness:** If desired, change the cross-section thickness using the Display-Parameters menu item.

## 6. View and Draw Cross-sections

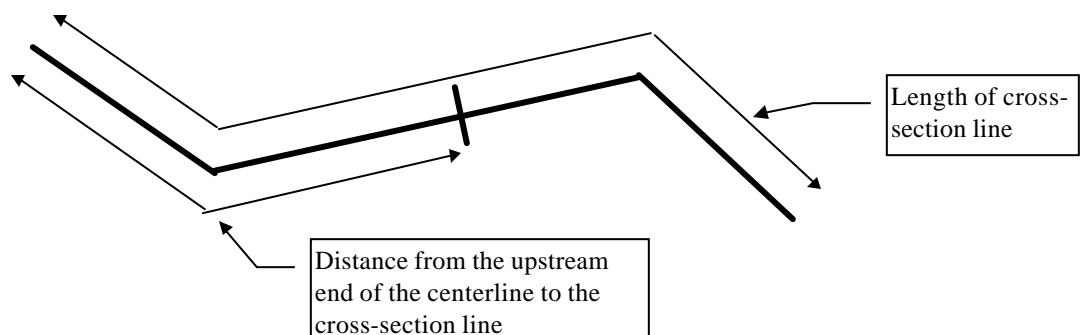
The next step is to draw a line through the points in cross-section view (Figure 6-7). The coordinates of these points are used by the CSDP to calculate *cross-section conveyance characteristics*. The toolbar on the cross-section window contains buttons for coloring the data points and editing the cross-section drawing.

Each cross-section is saved along with its channel number and its normalized distance along the channel from the upstream end. The normalized distance is the distance from the upstream end of the centerline to the cross-section line divided by the length of the cross-section line (Figure 6-8).










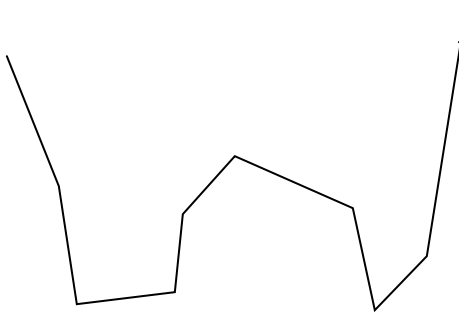
**Figure 6-7: Bathymetry data, Cross-section view with cross-section drawing**



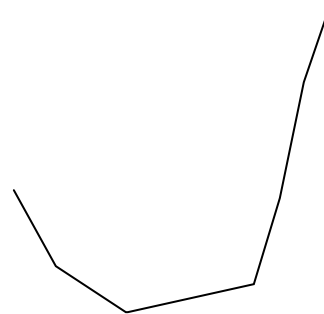
**Figure 6-8: The distance from the upstream end of the centerline to the cross-section line and the length of the cross-section line**

- 1) **Display the data in the cross-section view** by clicking the  button. The data are displayed with respect to a relative coordinate system. The origin of the coordinate system is located at the intersection of the centerline and the cross-section line. The horizontal axis is the distance in feet along the cross-section line. The vertical axis is the elevation in feet with respect to NGVD 1929.
- 2) **Add points:** click on the  button to turn on the add point mode.
- 3) **Edit points:** To insert, move, or delete points, click on the appropriate buttons, which are , , and , and click on the point(s) to be inserted, moved, or deleted. The **keep** button will save all of your changes in memory (not to a file). The **restore** button will undo all of your changes since the last time the **keep** button was clicked. The dX and dY buttons are used to move the cross-section drawing in the horizontal or vertical directions. To use this feature, enter a value (positive or negative) in the text field next to the dX or dY buttons and click the button. This feature is useful when two data sets are offset and you want to see how your drawing lines up with each of them.
- 4) **Draw a cross-section** through the data points by clicking on locations with the mouse. Try to use no more than 10 points. Using more than 10 points could increase Hydro's memory requirements and reduce its speed.
  - A) Avoid negative dconveyance between -5 and +15 feet(NGVD 1929) (Section 5).
  - B) Horizontal line segments above the bottom of the channel are acceptable. When cross-section properties are calculated, one of the elevations of the line segment will be increased by 0.01 ft (Horizontal line segments above the bottom are not allowed in cross-section property calculations because only one layer is allowed per elevation). A line segment that appears to be horizontal on the screen may not be exactly horizontal.
  - C) Avoid large changes in bottom elevation and area(NGVD 1929) within channels. Large changes in area within a channel could prevent Hydro from converging(Section 5).
  - D) "W" shaped cross-sections are acceptable(Figure 6-9a).
  - E) Avoid "J" shaped cross-sections. A "J" shaped cross-section will have low wetted perimeter values at higher elevations(Figure 6-9b).
  - F) The box above the Metadata window contains cross-section conveyance characteristics calculations. The calculations shown are for the elevation that is displayed in the box. These values are updated whenever the cross-section drawing is



modified or the elevation is changed. Click on the Change Elevation button to change the elevation.



**Figure 6-9a: “W” shaped cross-sections are acceptable**



**Figure 6-9b: “J” shaped cross-sections should be avoided**

- 5) **Add metadata if necessary.** The right hand side of the window is for metadata. Metadata is used to describe the cross-section drawing. Metadata should be included whenever it is not obvious why the cross-section was drawn the way it was. For example, if the cross-section is modified to simulate proposed dredging, the cross-section drawing will not line up with the data.
- 6) **Exit cross-section view** by clicking the  button. If you have made any changes to the cross-section, you will be asked if you want to save these changes. At this point, changes will only be saved in memory and will not be written to a file.
- 7) **Save your work to a network file** by selecting Network-Save or clicking the  button or selecting the Network-Save As menu item. A network file should have a .cdn extension.

## Cross-section plots

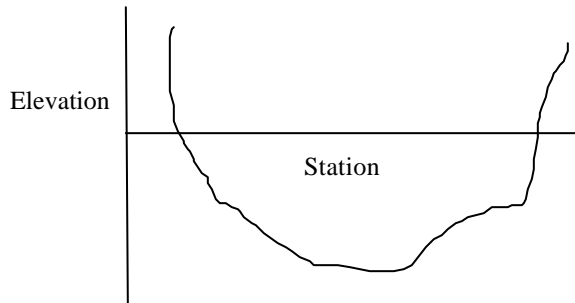
Cross-section plots consist of a series of points plotted on a graph(Figure 6-10). To use the CSDP to calculate cross-section properties for a given cross-section plot, estimate station and elevation coordinates of each point in the plot and follow the following procedure for processing cross-section station and elevation coordinates.

## Cross-section station and elevation coordinates

To use cross-section station and elevation coordinates, it is necessary to make a network file(Figure 6-11).

### Example

Given the following cross-section plot



**Figure 6-10: Cross-section plot. User needs to estimate station and elevation coordinates.**

Estimated station and elevation coordinates:	
Station	Elevation
5	15
10	-10
30	-30
50	-40
100	-20
110	10
use a text editor to make the following network file(do not include line numbers):	
1:1	
2: "1" 2 1000,1000 5000,1000 1	
3:     " " 6 5,15 10,-10 30,-30 50,-40 100,-20 110,10 10000 10000	
Line 1:	the number of centerlines in the file
Line 2:	the centerline name(channel number) in quotes
	the number of centerline points
	two sets of XY coordinates—values do not matter in this case
	number of cross-sections in centerline
Line 3:	empty quotes mark the beginning of a cross-section
	number of cross-section coordinates
	cross-section coordinates (station, elevation)
	distance along centerline—value does not matter in this case
	cross-section line length—value does not matter in this case

**Figure 6-11: Using station and elevation coordinates to make a network file**

### 3. Preparing Irregular Cross-Section data for DSM2

output

irregular\_xsects.inp


\*.txt files

problems to be avoided

-dconveyance

horizontal line segments

The output from the CSDP is used as input for DSM2. DSM2 irregular cross-section input files consist of cross-section property tables (\*.txt files) and files containing IRREG\_GEOM input sections. For more information on DSM2 input files, see Chapter 5.

Load a network file (.cdn) using Network-Read. The file *delta.cdn* is the main network file that is used by the Delta Modeling Section. Click the  button. You

will be asked to select a directory for cross-section output files(\*.txt). After selecting the directory, enter 1 or more characters in the “filename” text field (your entry will not be used, but Java’s FileDialogBox will not accept your input unless you do this). This will write all of the cross-section files(\*.txt), a new landmark file(\*.cdl), and a file called *irregular\_xsects.inp*, which contains the IRREG\_GEOM input section. The new landmark file can be used in the future for locating cross-sections when you use the CSDP. All files will be written to the directory in which you started the application (with the exception of the cross-section files, which will be written to the directory that you selected). Using a text editor, open the file *irregular\_xsects.inp* and change the path name in the FILENAME field.

```

The following output from the CSDP

IRREG_GEOM
CHAN      DIST      FILENAME
   6      0.62093    ./6_0.62093.txt
   7      0.25863    ./7_0.25863.txt
END

becomes

IRREG_GEOM
CHAN      DIST      FILENAME
   6      0.62093    c:\input\6_0.62093.txt
   7      0.25863    c:\input\7_0.25863.txt
END

```

**Figure 6-12: Change the pathname in the FILENAME field**

#### 4. DSM2 Input (output files from the CSDP) IRREG\_GEOM input section Irregular Cross-section files(\*.txt)

To use irregular cross-sections, Hydro requires an IRREG\_GEOM input section and irregular cross-section files (Chapter 5).

#### **IRREG\_GEOM input section**

The *irregular\_xsects.inp* file contains the IRREG\_GEOM input section (Chapter 5). This file is used to assign cross-sections to DSM channels and to a locations within the channels.

IRREG_GEOM		
CHAN	DIST	FILENAME
6	0.62093	./6_0.62093.txt
7	0.25863	./7_0.25863.txt
7	0.86019	./7_0.86019.txt
8	0.13301	./8_0.13301.txt
9	0.18331	./9_0.18331.txt
9	0.89620	./9_0.89620.txt
11	0.05921	./11_0.05921.txt
END		

**CHAN** defines the channel number in the DSM model grid.

**DIST** defines the location of a cross-section within a channel. DIST can be the *normalized* distance along the channel measured from the upstream end(a value between 0 and 1), 0, MID, or LENGTH. If DIST is between 0 and 1, the normalized distance will be multiplied by the actual channel length specified in the CHANNELS input section. The normalized distance is calculated by dividing the distance from the upstream end of the centerline(Figure 6-6) to the cross-section line by the total length of the centerline.

**FILENAME** is the complete pathname of the irregular cross-section file. It will usually be necessary to change the pathname to the directory in which the cross-section files are stored. The filename consists of a channel number followed by an underscore followed by the normalized distance followed by a txt extension.

**Figure 6-13: IRREG\_GEOM input section**

The IRREG\_GEOM input section is typically stored in a file called *irregular\_xsects.inp* and is created by the CSDP when the Network-Calculate menu item is selected. The IRREG\_GEOM section that is written by the CSDP will always assign cross-sections to the locations defined by their filenames. The filename of a cross-section describes the DSM channel number and the normalized distance along the channel(Figure 6-13).

To prevent interpolation or the use of rectangular cross-sections, it is sometimes desirable to copy cross-sections to other locations. Cross-sections can be copied to other locations in the same channel or in other channels. To do this, an additional IRREG\_GEOM input section(Figure 6-14) can be created manually and stored in a separate file, which might be called *irregular\_xsects\_copy.inp*. The file can also be used to include cross-sections which are not included in the network file.

```

IRREG_GEOM
CHAN      DIST      FILENAME
# COPIED CROSS-SECTIONS
327        0
C:\input\327_0.44122.txt
327      LENGTH
C:\input\327_0.44122.txt
366        0
C:\input\366_0.54505.txt
366      LENGTH
C:\input\366_0.54505.txt
422        0          C:\input\422_0.88014.txt

# NON-GEOREFERENCED CROSS-SECTIONS
# USGS bathymetry for Upper SJR; not in
CSDP
1          0          C:\input\1u.txt
1          MID        C:\input\1m.txt
2          0          C:\input\2u.txt
3          0          C:\input\3u.txt
3          MID        C:\input\3m.txt
3          LENGTH     C:\input\3d.txt
4          0          C:\input\3d.txt
4          LENGTH     C:\input\3d.txt
5          0          C:\input\6m.txt
5          LENGTH     C:\input\6m.txt

```

**Figure 6-14: IRREG\_GEOM input section with cross-sections assigned to locations other than the locations defined by their filenames**

All files which contain IRREG\_GEOM input sections that you wish to use for a model run must be listed in the INP\_FILES input section (Chapter 5).



## Irregular cross-section files(\*.txt)

A cross-section file is written for every cross-section drawn by the user. The file consists of a table of area, width, wetted perimeter, hydraulic radius, x centroid, and z centroid values for each unique elevation in the cross-section(Figure 6-15).

Cross-section: 105_0.75640						
Elev(NGVD 1929)	A	P	W	Rh	Xc	Zc
=====						
100.00	108887.6	1164.4	1026.1	93.5	86.6	47.7
-1.43	9631.0	939.9	931.0	10.2	-1.4	-6.7
-8.86	3481.9	728.5	724.1	4.8	-94.7	-11.7
-12.13	1451.9	519.6	517.5	2.8	-182.9	-14.4
-13.05	1003.7	458.6	456.7	2.2	-227.6	-15.6
-13.75	706.3	394.9	393.2	1.8	-275.8	-16.7
-14.00	636.5	167.0	165.3	3.8	-288.8	-17.1
-14.68	541.1	116.6	115.1	4.6	-300.5	-17.6
-21.64	0.0	40.4	40.4	0.0	-308.7	-21.6

**Figure 6-15: Table of cross-section properties: created by CSDP, used by Hydro**

## 5. Using Irregular Cross-Sections with DSM2-Hydro

### Cross-Section Interpolation

#### Actual vs Requested deltax

#### Problems to avoid

##### negative dConveyance

##### interpolated negative dConveyance

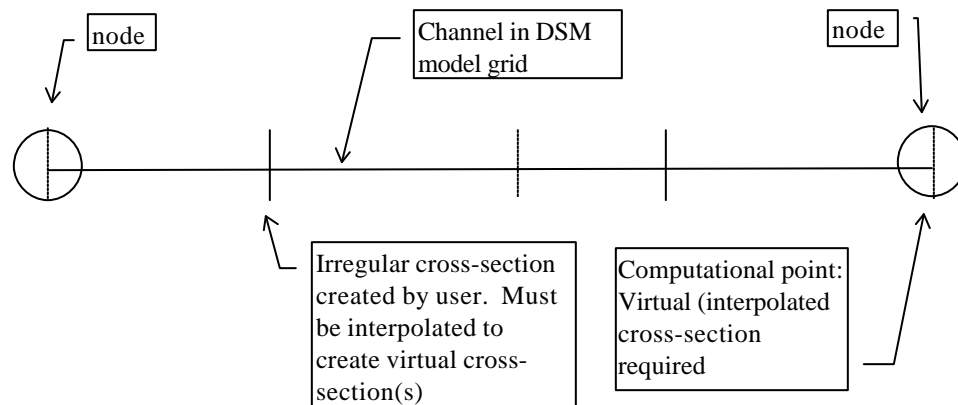
##### convergence

### Troubleshooting Geometry Problems

This section describes how DSM2-Hydro uses irregular cross-sections. Some of the problems which can cause a model run to fail are negative dConveyance, interpolated negative dConveyance, and convergence.

## Cross-section Interpolation

Cross-sections have to be interpolated by Hydro for every computational point in the model grid before they can be used by FourPt. Interpolated cross-sections are also known as *virtual cross-sections* (Figure 6-16). The number of computational points in each channel depends on the *actual* value of delta X, which depends on the channel length and the *requested* value of delta X.



**Figure 6-16: DSM channel with (user-generated)irregular cross-sections and virtual cross-sections**

### Actual vs Requested deltax

The scalar input variable **deltax**(Chapter 5) is called the *requested value of deltax* ( $\Delta X_r$ ). The actual value of deltax used by hydro ( $\Delta X_a$ ) in each channel depends on  $\Delta X_r$  and the channel length. The following equation is used to calculate  $\Delta X_a$ :

$$\Delta X_a = \text{length} / (2 * \text{int}(\text{length} / \Delta X_r))$$

(Note: the int function truncates)

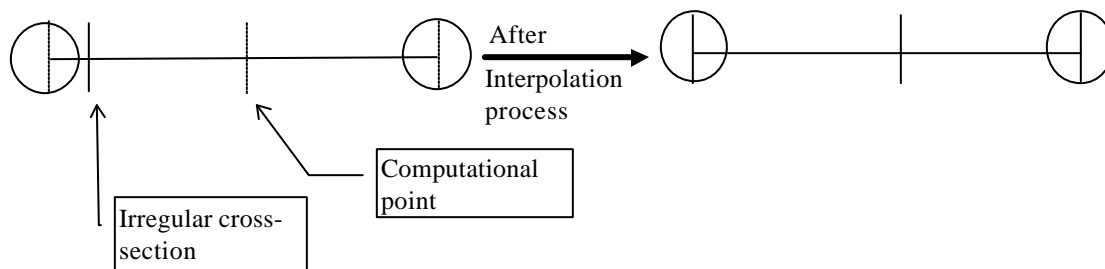
Rectangular cross-sections are used in channels which do not have irregular cross-sections. To limit the use of rectangular cross-sections, Hydro moves and copies cross-sections (Note: even with the use of irregular cross-sections, it is still necessary to define at least two rectangular cross-sections for every channel in the model grid). The following rules apply to the moving and copying of cross-sections:

### Rules for copying, moving, and interpolating cross-sections

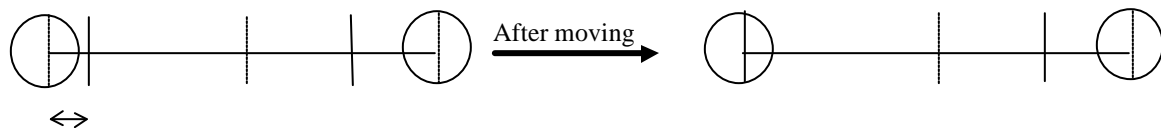
1. Any channel with one or more irregular cross-sections will not use rectangular cross-sections (Figure 6-17). A channel with no irregular cross-sections will only use rectangular cross-sections for interpolation. It is possible to assign two or

more different rectangular cross-sections to a channel, but this is not typically done.

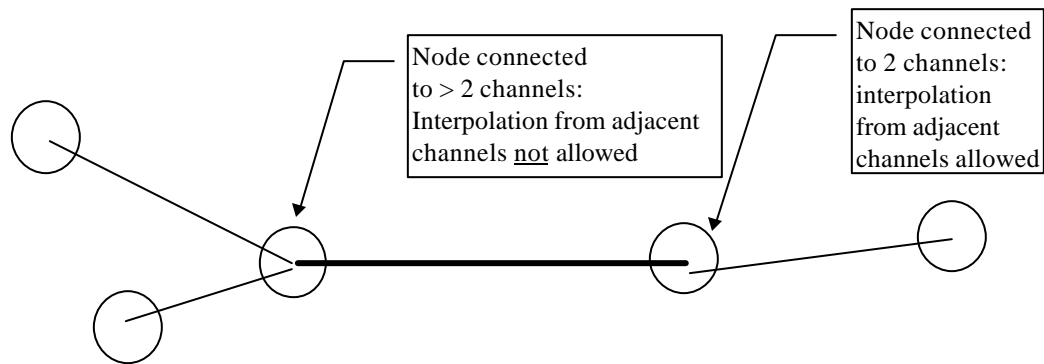
- 2 . For each node: If the distance from the node to the nearest cross-section is within 5% of the channel length, then the cross-section will be moved to the end of the channel which is adjacent to the node(Figure 6-18). This is done to prevent interpolation from adjacent channels.
- 3 . Cross-sections can only be interpolated across nodes if the node is connected to 2 channels(Figure 19).
- 4 . If a channel has 1 or more irregular cross-sections which cannot be moved (rule #2) and no cross-sections are available for interpolation in the adjacent channel (rule #3), the cross-section(s) nearest to the nodes will be copied to end of the channel adjacent the node. A moved cross-section can be used by an adjacent channel for interpolation; a copied cross-section cannot.



**Figure 6-17: A channel with one or more irregular cross-sections will not use any rectangular cross-sections. The irregular cross-section(s) in the channel will be copied, moved, and/or used for interpolation with cross-sections in adjacent channels**



**Figure 6-18: If the distance from the node to the nearest cross-section is within a distance of 5% of the channel length, then the cross-section will be moved to the node**



**Figure 6-19: Interpolation from adjacent channels(across nodes) is only allowed if the node is connected to two channels**

Interpolation occurs in three stages. The first two stages occur while Hydro is processing input data. The purpose of the first two stages is to create a lookup table(Figure 6-20) that is used to reduce the number of interpolations that occur while FourPt is running. The three stages are:

- 1 . A list of all unique elevations is made for each channel. Cross-section properties are interpolated in the vertical direction for every elevation in this list. If necessary, cross-sections are extrapolated in the vertical direction using the `levee_slope` value that is specified in the SCALAR input section(Chapter 5).
- 2 . Cross-section properties and bottom elevations are interpolated in the horizontal direction to create virtual cross-sections.
- 3 . During a model run, cross-section properties are interpolated in the vertical direction for the specified water surface elevation value.

To create a virtual cross-section for each computational point, the nearest two cross-sections on either side are interpolated. Cross-sections from adjacent channels are used if there are two channels connected to the adjacent node. Cross-sections that are interpolated or are copies of other cross-sections are never used for interpolation.

For a listing of virtual cross-sections, change the value of `printlevel` in the SCALAR input section to 5, change the length of the run to 1 hour, and run Hydro(Chapter 5). (Note: When *printlevel* is set to 5, Hydro will produce a large output file that could fill your hard disk. For this reason, it is best to avoid running Hydro for more than 1 hour with *printlevel* set to 5.). An ascii file will be written which contains a listing of all cross-section properties in all virtual cross-sections.

VIRTUAL CROSS-SECTION LOOKUP TABLE					
Channel	1,Virtual Section	1			
Height	Width	Area	Wet_p	Z Centroid	min_elev
0.00	192.00	0.00	192.00	0.00	-5.10
5.10	192.00	979.20	202.20	2.55	-5.10
100.00	192.00	19200.00	392.00	50.00	-5.10
Channel	1,Virtual Section	2			
Height	Width	Area	Wet_p	Z Centroid	min_elev
0.00	192.00	0.00	192.00	0.00	-5.10
5.10	192.00	979.20	202.20	2.55	-5.10
100.00	192.00	19200.00	392.00	50.00	-5.10
Channel	1,Virtual Section	3			
Height	Width	Area	Wet_p	Z Centroid	min_elev
0.00	192.00	0.00	192.00	0.00	-5.10
5.10	192.00	979.20	202.20	2.55	-5.10
100.00	192.00	19200.00	392.00	50.00	-5.10

**Figure 6-20: Virtual cross-section lookup table for channel 1**

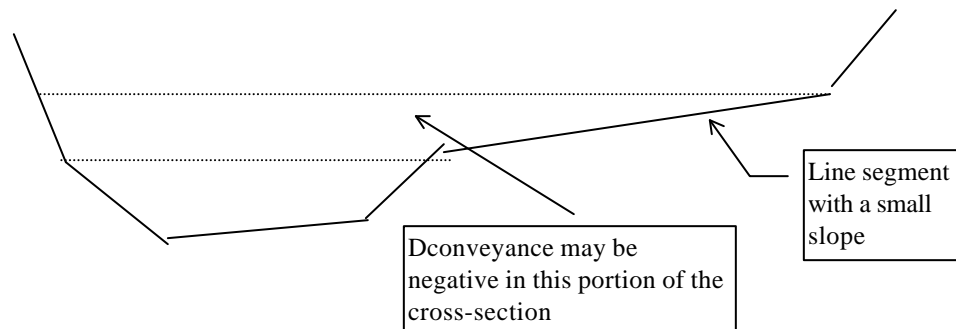
## Problems to avoid when using irregular cross-sections with DSM2

### Convergence

When using irregular cross-sections, Hydro will often fail to converge in a number of channels. If the failures are large enough, a channel will overflow or dry up. Hydro will not converge if there are large changes in cross-sectional area between virtual cross-sections that are in the same channel. To avoid convergence problems, make sure that for every channel, the ratio of the largest virtual cross-sectional area to the smallest is less than 2.0. Running Hydro with printlevel set to 5 produces a list of all channels that may have convergence problems.

## Negative dconveyance

A Hydro run will fail if the water level in any virtual cross-section enters a portion of the cross-section that has negative dConveyance. dConveyance is the derivative of conveyance with respect to height. dConveyance can be negative if a line segment has a very small slope (close to horizontal), which causes a large change in wetted perimeter with respect to elevation. It is the user's responsibility to eliminate negative dConveyance in portions of cross-sections which are in the anticipated water surface elevation range.



**Figure 6-21: Negative dConveyance can occur if the slope of a line segment is very small**

To detect negative dConveyance, set *printlevel* to 5 or greater (Chapter 5), include a line in the IO\_FILES input section to write output to an ascii file of TYPE none, and run Hydro. The ascii file will contain the following list of interpolated layers with negative dConveyance:

Warning: The following cross-sections have negative dconveyance						
channo	vsecno	depth	min_elev	elevation	cond 0	cond 1
-----						
86	2	20.51	-26.23	-5.72	10160.62	*****
86	2	20.52	-26.23	-5.71	*****	15889.29
91	2	28.06	-29.19	-1.13	14857.46	-302624.69
91	2	28.07	-29.19	-1.12	286844.50	15631.51
95	3	19.58	-25.83	-6.25	12255.03	-856674.94
95	3	19.59	-25.83	-6.24	667307.25	16002.04

**Figure 6-22: Output from Hydro: list of virtual cross-sections with negative dConveyance**

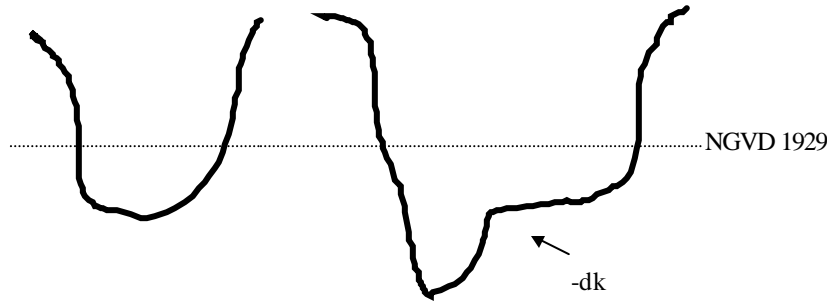
If any cross-sections have negative dConveyance in the range of  $-5 < Z < 15$  ft, they will be identified by this list. It is acceptable to have negative dConveyance only if the water level will never enter the portion of the cross-section that has negative

dConveyance. If it is necessary to eliminate negative dConveyance, look at the magnitude of the negative dConveyance. The magnitudes of dConveyance for each layer are listed in the cond 0 and cond 1 columns. If it is very large, then you will have to make a big change. Negative dConveyance is adjusted in two ways:

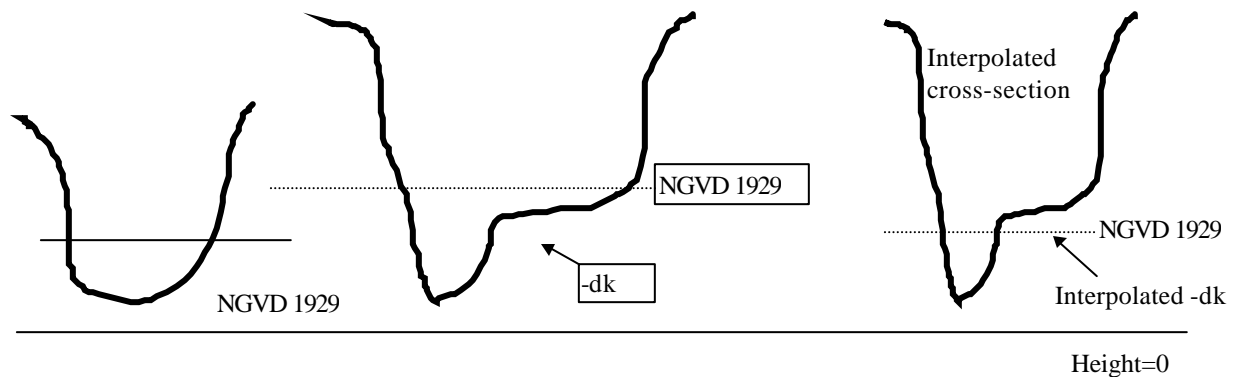
- 1 . Change the slope of a line segment by adding, moving, or removing points
- 2 . Adjusting bottom elevations and/or changing the slopes of line segments if the problem is caused by *interpolated negative dConveyance*.

### **Interpolated negative dConveyance**

The CSDP will identify *layers* between -5 and +15 ft(NGVD 1929) in all *virtual*(interpolated) cross-sections that have negative dConveyance (a layer is a row of data in the cross-section property table). The virtual cross-sections that Hydro uses may contain negative dConveyance at elevations between -5 and +15 ft even if the two cross-sections used in the interpolation do not. Before cross-sections are interpolated (Figure 6-23a), the bottom elevation is subtracted from all the elevations in the cross-sections, which converts the elevations to heights. The bottoms of the cross-sections are now at the same height(zero). If there is a big difference in bottom elevations, the interpolated cross-section could have negative dConveyance between -5 and +15 (Figure 6-23b).



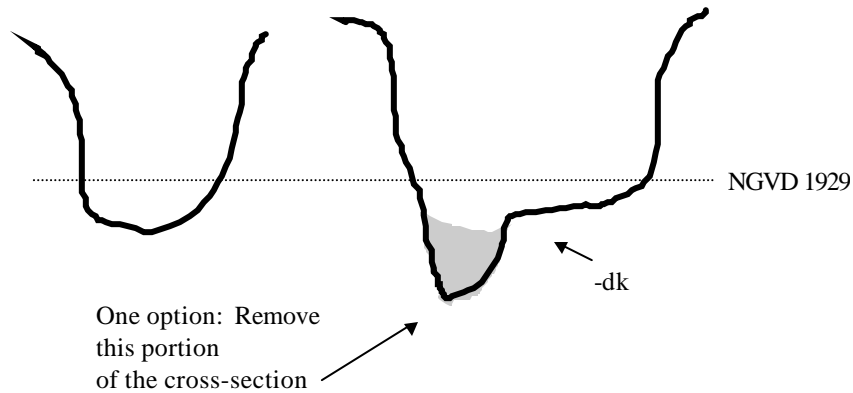
**Figure 6-23a: Cross-sections with *different* bottom elevations before subtracting bottom elevation. Negative dconveyance (-dk) exists *below -5ft***



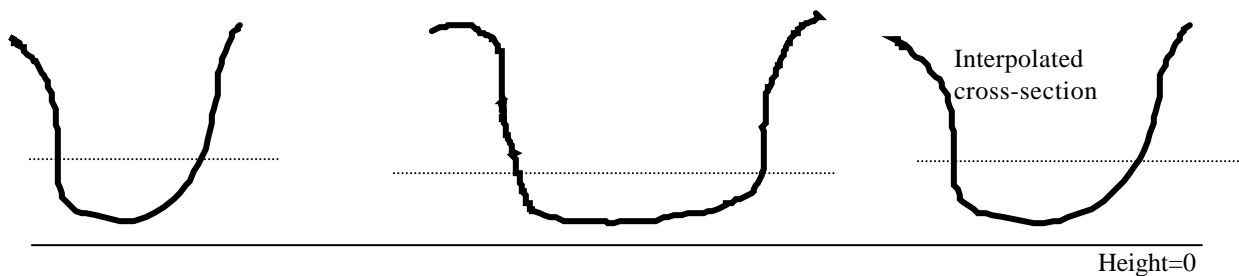
**Figure 6-23b: Cross-sections with *different* bottom elevations after subtracting bottom elevation; interpolated cross-section with interpolated negative dconveyance near NGVD 1929**

The best solution to this problem is to adjust the bottom elevations in one or both of the cross-sections so that they are not so far apart (Figure 6-24a). The resulting interpolated cross-section (Figure 6-24b) would not have negative dConveyance in the range of -5 ft to 15 ft. Large changes in bottom elevation within a channel could indicate that one or more of the cross-sections may not be representative.





**Figure 6-24a: Cross-sections with different bottom elevations before subtracting bottom elevation: shaded area could be removed to prevent interpolated negative dConveyance**



**Figure 6-24b: Cross-sections before subtracting bottom elevation-shaded area was removed to prevent interpolated negative dconveyance**

To detect interpolated negative dConveyance, it is necessary to run Hydro with the scalar variable *printlevel* set to 5 or greater(Chapter 5).

## Troubleshooting Geometry Problems

When a Hydro run fails due to a problem with the geometry, you will get an error message that includes the values of two variables, X and H, where

X is the location of the virtual cross-section in feet, measured from the upstream end

H is the distance from the bottom of the virtual cross-section to the water surface

### 1. Negative dConveyance

A Hydro run will fail if the water surface enters a portion of any virtual cross-section in which dConveyance is negative. If a model run fails due to

negative dConveyance, check the value of H. If H is outside the expected range of water surface elevations, then the problem is most likely lack of convergence, which may or may not exist in the channel that contains the cross-section with negative dConveyance. If H is within the expected range of water surface elevations, then you need to adjust the cross-section to remove negative dConveyance.

It is necessary to eliminate negative dConveyance in every portion of every cross-section that is within the expected range of water surface elevations. Running Hydro through a wide range of water surface elevations is not sufficient to test for negative dConveyance. It is possible for the water surface to skip over a portion of a cross-section in which dConveyance is negative, and to continue running. This can happen when the portion of the cross-section is very thin (Figure 6-25).

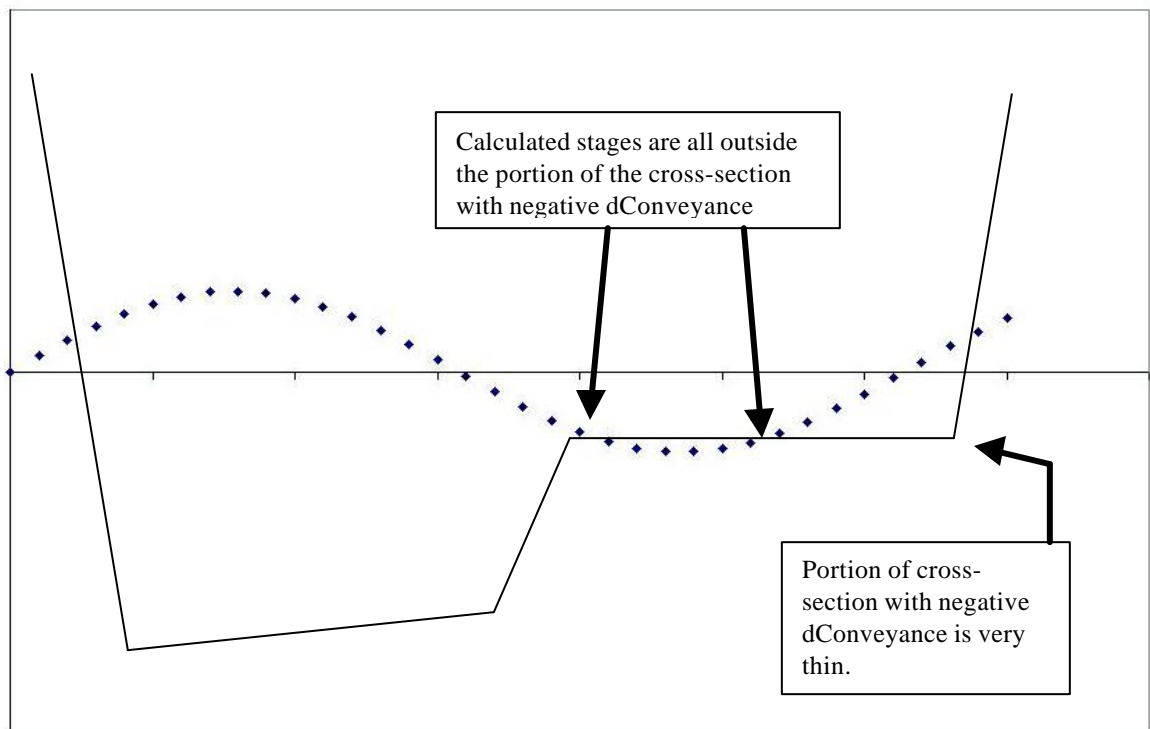


Figure 6-25: Calculated stages skipping a portion of a cross-section with negative dConveyance

## 2. Channel dries up

When a channel dries up, first check the value of H, which will be negative. If the absolute value is more than 1 ft, then the problem is most likely convergence. If the absolute value is small, the problem could also be convergence but other possibilities must be considered:

- A. The stage in the channel may be low because inflow to the system is low. If this is the case, you may need to lower the bottom elevations of the cross-section in this channel.
- B. There may be incorrect gate input. If a gate is not operating correctly, it could cause a portion of the system to drain.
- C. Clifton Court Forebay may not be operating correctly.
- D. If a channel is drying up near the beginning of a run, you may need to adjust initial stage conditions. A channel can dry up if the initial stage in the channel or in another channel is too low or too high.

### 3. Channel overflows

When a channel overflows, there are three possibilities:

- A. The model is not converging.
- B. There may be incorrect input. Make sure gates are operating correctly.
- C. Initial stage conditions need to be adjusted.

Convergence is almost always the cause of a channel overflowing.

## 6. Other features not related to DSM2

Export Network

Export to Station/Elevation format

Export to 3D format

Open Water Area Calculations

The CSDP includes two options for exporting networks. Export to Station/Elevation format is used to create a file that lists cross-section coordinates in HEC-2 format. This file can then be used as input for Open Water Area Calculations. To create a file that contains only the centerline numbers and the length of each centerline, select the Network-Network Export Options-for Station/Elevation format, only export channel lengths checkbox menu item.

To create file with cross-section coordinates converted to UTM, select the Network-Export to 3D format menu item.

## Open Water Area Calculations

This feature was developed for a study that compared floodplain and river hydrology. The purpose was to compare aquatic species habitat in the Sacramento River vs Yolo Bypass. You do not need to load a bathymetry data file to perform the calculations, just start the CSDP and select the Tools-Open Water Area Calculations menu item. The floodplain or river is treated as a reservoir or open water area. It works by reading in cross-sectional data in a station-elevation format (station=distance across the channel from a reference point, usually near one of the banks). Using the following input:

### Cross-sections in HEC-2 format

Cross-section input must be in HEC-2 format. If you want to use cross-sections created with the CSDP as input, you must first export the network file:

1. Load a network file or create a new network by drawing one or more cross-sections.
2. Select Network-Export to Station/Elevation Format You will be asked to specify a path and filename for the output file.
3. Select a directory and enter a filename that ends in .se. A file will be created that contains each cross-section in the network in HEC-2 format. Each cross-section will be given a name that consists of its centerline name and its distance along its centerline.

### **Stage and flow data**

Open water area calculations include area, volume, width-weighted hydraulic depth, wetted area in a specified range, and hydraulic residence time for the entire reach. Stage data are specified for any number of stations along the open water area. Stage values are interpolated between stations at for each cross-section. If a cross-section is not between two stations, then stage values are extrapolated.

### **Area(square feet)**

Top width is calculated for each cross-section at the interpolated water surface elevation. These areas are integrated over the entire reach to approximate the area of the reach.

### **Volume(cubic feet)**

Cross-sectional area is calculated for each cross-section at the interpolated water surface elevation. These volumes are integrated over the entire reach to approximate the volume of the reach.

### **Width-Weighted Hydraulic Depth(feet)**

Hydraulic depth and top width are calculated for each cross-section at the interpolated water surface elevation. The width-weighted hydraulic depth is a top width weighted average of the hydraulic depth of each cross-section.

### **Wetted area in specified range(square feet)**

Wetted perimeter is calculated for each cross-section at the interpolated water surface elevation and at 6 feet below(the specified range) the interpolated water surface elevation. The difference between the two wetted perimeter values was calculated for each cross-section; these differences were integrated over the entire reach to calculate wetted area in the range of 6 feet below the water surface to the

water surface. (Note: for the Yolo Bypass study, a value of 6 feet was requested. This value is currently "hard-coded" into the program; however it would be possible to modify the program in the future to allow the user to specify a value).

### **Hydraulic residence time(seconds)**

The hydraulic residence time is estimated by dividing the volume of the reach by the specified flow rate.

### **Input files**

#### **1. Open water Area File (\*.owa, Required)**

This file contains all of the cross-sections that describe the open water area in HEC-2 format. Station and elevation values are assumed to be in feet. Here is an excerpt from all.owa, a file which contains Yolo Bypass cross-sections:

```
X1 984    53  0.00  0.00  0.00  0.00 984.25
0      -0.4
720.19   -0.38
737.13    4.08
781.04    4.11
807.99    4.58
848.99    4.9
898.54    5.02
```

The first number after the X1 is the distance in feet of the cross-section from the upstream end of the open water area. The cross-sections must be in order from upstream to downstream.

#### **2. Time Series Data File (\*.tsd, required)**

This file consists of two sections. Each section begins with a row of headers and ends with the "END" keyword. The first section identifies station names and their distances in feet from the upstream end of the open water area. The stations should be in order from upstream to downstream. If a station is upstream from the upstream end of the reach, use a negative value. The second section consists of one line for each date. The dates do not have to be in order, and there can be gaps between dates. Each line in this section consists of a date, the measured stage in feet at this location, and the outflow in cfs from the open water area. If a stage value is missing, use the value -9999.00.

Here is an excerpt from gageheights.tsd:

Station	Distance
---------	----------

```

rio          -30000
liberty      34500
lisbon       89500
yolo         169000
fremont      198000
END

```

Series 1998

```

Date  Rio  Liberty      Lisbon      Yolo  Fremont  Flow
1/1/98 5.49 -9999.00    6.52  12.37  16.39  390
1/2/98 5.82 -9999.00    6.86  12.36  16.41  384
1/3/98 5.77 -9999.00    6.90  12.41  16.77  386
1/4/98 5.68 -9999.00    6.92  12.58  18.19  394
1/5/98 5.10 -9999.00    6.39  13.11  21.77  461
END

```

### 3. Toe drain file (\*.txt, optional)

This file is read only if the option *Use Toe Drain Restriction* is selected. The toe drain file is used only for Yolo bypass calculations. This was an attempt to simulate the way the Yolo Bypass fills. A station and elevation value are specified for each cross-section. When the cross-section is filling, all of the water stays in the toe drain area until it reaches the elevation specified in the toe drain file. If the elevation moves above this point, the water is allowed to “spill over” into the rest of the cross-section.

Here is an excerpt from toedrain.txt:

```

46395 2484.82    5.15
47388 2461.07    5.8
END

```

### Options

The open water area calculations dialog box defines the following options for Open Water Area Calculations:

- Echo Time Series input (default yes) This option will put time series input in the output file.
- Echo Xsect Input (default no) This option will put all cross-section information from the .owa file in the output file. This was mainly used for debugging.
- Echo Toe Drain Input (default no) This option will put all toe drain input into the output file.

- Print Xsect Results(long)(default no) - This option will print the results for every date for every cross-section and will produce a large amount of output.
- Use Fremont Weir - This option is only used for Yolo Bypass calculations. If the stage at Fremont Weir is below 33.5 ft with respect to NGVD 1929, (the elevation of the weir), then the Yolo stage is assigned to the Fremont location.
- Use Toe Drain Restriction(default yes) - This option is described above.

## Performing Open Water Area Calculations

1. Select the Tools-Open Water Area Calculations menu item.
2. A dialog box will appear on the screen. Click on the "browse..." buttons to select the input files you wish to use. Click on the radio buttons to specify the options you wish to use. If "use Toe Drain restriction" is selected, you must specify a toe drain file.

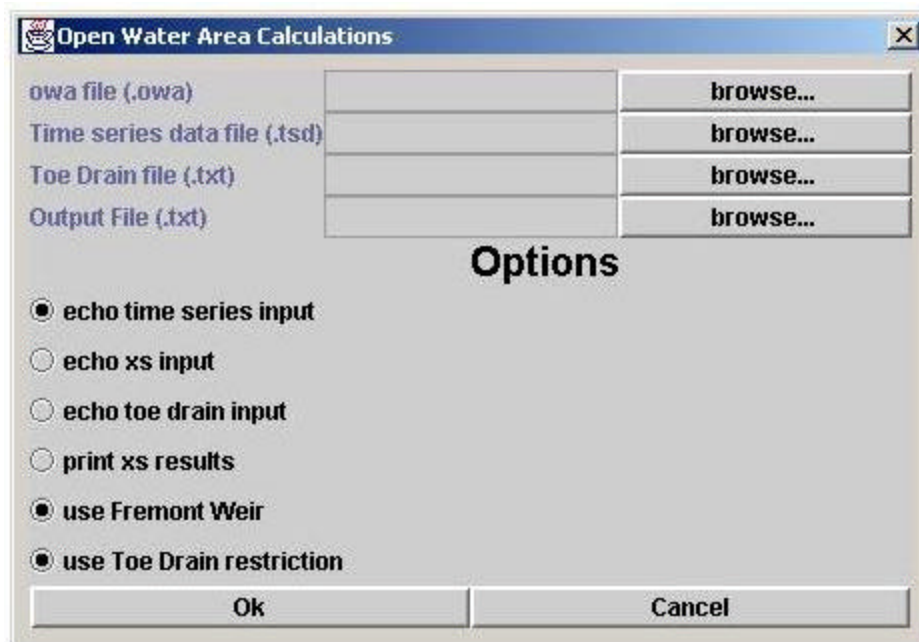


Figure 6-26A: Open Water Area Calculations Dialog Box

When all filenames are selected, the filenames will appear in the text fields:

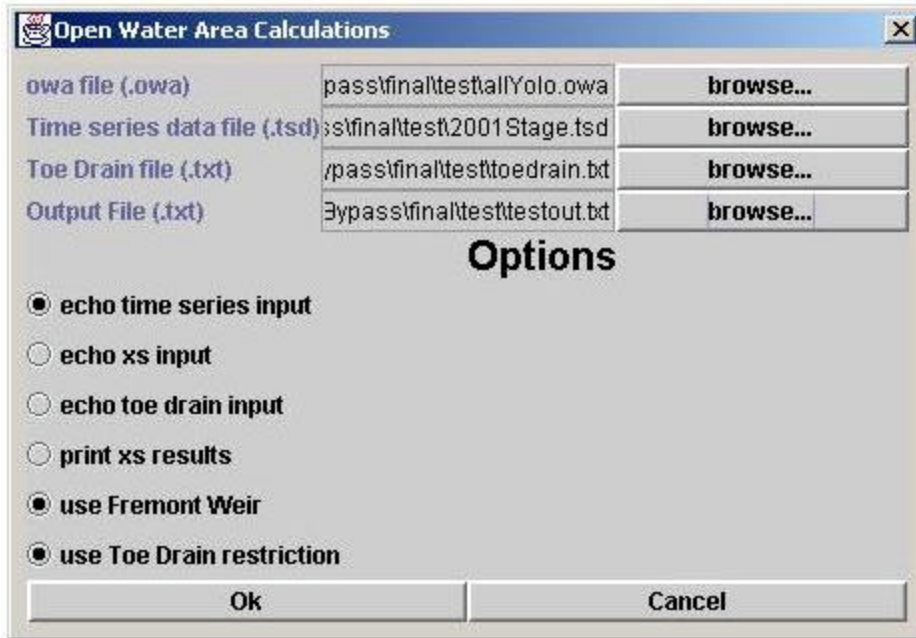


Figure 6-26B: Open Water Area Calculations Dialog Box with input filenames specified

3. Click on the Ok button when you are finished. Calculations will then be performed and output will be generated. Look at the shell from which you started the csdp to monitor progress.

Figure 6-27 is a sample Open Water Area Calculations output file. The information that is written to this file depends upon the options specified in the dialog box (Figure 6-26B). The following quantities are included in the output section of the output file:

- Date - all the dates that are specified in the time series input
- Area - surface area of the water body,  $\text{ft}^2$
- Volume - volume of the water body,  $\text{ft}^3$
- Wwhd - width-weighted hydraulic depth, ft
- Waisr - wetted area in specified range (top 6 feet of wetted area),  $\text{ft}^2$
- residence time - hydraulic residence time, seconds



```

Program options
-----
echoTimeSeriesInput  true
echoXsectInput       false
echoToeDrainInput    false
printXsectResults    false
useFremontWeir        true
useToeDrainRestriction true
-----

time series input
-----
Station Distance
Rio      -30000.0
Liberty  34500.0
Lisbon   89500.0
Yolo     169000.0
Fremont  198000.0
end

Date      Rio      Liberty  Lisbon  Yolo    Fremont  flow
01/01/2001 0.68      0.83    1.08    9.82    12.09    43.0
.
.
.
06/22/2001 1.87      1.99    2.13    9.42    12.51    43.0
06/23/2001 2.15      2.16    2.41    9.37    12.44    43.0
end

wwhd = width weighted hydraulic depth
waivr = wetted area in specified range = 0 to 6.0

date      area      volume  wwhd    waivr    residence time
-----
01/01/2001 6.9540272E7 3.1228936E7 NaN      7.153288E7 726254.3
.
.
.
06/22/2001 2.65840976E8 2.41152016E8 NaN      2.67787712E8 5608186.5
06/23/2001 2.70254048E8 2.93795488E8 NaN      2.72183008E8 6832453.0

```

Figure 6-27: Open Water Area Calculations output file